Original Papers

Point-of-Admission Serum Electrolyte Profile of Children less than Five Years Old with Dehydration due to Acute Diarrhoea

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Abstract: Background/Objective: Fluid, electrolytes and acid base disturbances are responsible for most deaths due to acute diarrhoea. The aim of this study is to describe the point-of-admission serum electrolyte profile of children with dehydration due to acute diarrhoea.

Methods: In this cross-sectional study, the serum electrolyte levels of 185 children with dehydration due to acute diarrhoea were assessed at the point of admission at the Diarrhoea Treatment and Training Unit of the University of Benin Teaching Hospital. The age of the study population ranged from 29 days to 59 months.

Results: Out of a total of 185 subjects, 30 (16.2%), 114 (61.6%), and 41 (22.2%) had severe, moderate and mild dehydration, respectively. In addition, hyponatraemic dehydration was the most common type of dehydration, accounting for 60.5% of cases. Metabolic acidosis and hypokalaemia occurred in 59.5% and 44.3% of cases, respectively. Only the serum bicarbonate level was significantly affected by degree of dehydration (p = 0.001). Age of more than 12 months and presence of vomiting were significantly associated with hyponatraemia (p = 0.005 & p = 0.02), while age of less than or equal 12 months and absence of vomiting were associated with metabolic acidosis (p = 0.04 & p = 0.03).

Conclusion: The degree of dehydration appears to be a good predictor of the occurrence of metabolic acidosis while age is a risk factor for hyponatraemia and metabolic acidosis.

Key words: Electrolytes, acid-base, dehydration, acute diarrhoea

INTRODUCTION

Acute diarrhoea may be defined as any sudden and significant increase in frequency and/or decrease in consistency of the stool of an individual lasting less than two weeks [1]. Patterns of stooling vary widely in young children, and diarrhoea represents a change from the norm [2]. Acute diarrhoeal disease accounts for millions of deaths each year in infants and young children, mostly in developing countries [3]. In the developed countries, it is also a common reason for presentation to general practice or emergency departments [4].

Worldwide, an estimated 1.7 billion cases of acute diarrhoea and nearly 700,000 deaths occur each year in children under 5 years [5]. In Nigeria, diarrhoea-related deaths among under-five children accounts for over 16% of under-five mortality and an estimated 194,000 deaths annually [6].

Diarrhoea-related deaths may result from immediate and/or long term consequences of the disease [7]. The immediate effects include fluid and electrolyte derangement with an upset in the body's acid-base regulation. Since extracellular fluid osmolality and volume are determined by sodium content, this ion plays a key role in water and electrolyte regulation. In this regard, the biochemical derangement in children with dehydration may be hyponatraemic, isonatraemic or hypernatraemic [8]. Other biochemical disturbances observed include hypokalaemia and metabolic acidosis.

However, in clinical settings, the degree of dehydration is often classified as mild, moderate or severe based on the estimated fluid loss and other clinical parameters [9]. Dehydration is the most frequent and dangerous complication responsible for morbidity and mortality in children with acute diarrhoeal disease. In the same vein, altered biochemical parameters have also been found to be closely related to prognosis [10]. When assessed at admission, these biochemical parameters provide valuable information for the optimal and specific management of the patient.

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A previous study done to access the serum electrolytes pattern of dehydrated children in our locality did not fully capture the at-risk population. Only malnourished children aged 2–24 months were recruited for that study [11]. As a result, this present study sought to describe the point-of-admission electrolyte profile and its relationship, if any, with the clinical stages of dehydration in children under five years of age.

METHODS

This was a prospective cross-sectional study undertaken at the Diarrhoeal Treatment and Training Unit (DTTU) of the University of Benin Teaching Hospital (UBTH) during the period from July 2012 to June 2014. All children aged between 29 days and 59 months admitted to the DTTU with a primary diagnosis of acute diarrhoeal disease were enrolled. However, those who received diuretics during the index illness prior to admission were excluded.

The data collection instrument was a structured interviewer-administered questionnaire that was pretested with modifications made prior to its use in the study. Information was obtained from parents/guardians of recruited children by the researcher and trained junior residents on a range of demographic and clinical parameters. The serum electrolytes and acid-base status of the subjects were performed following admission at the hospital laboratory using flame photometry. Ethical approval was obtained from the Ethics committee of the University of Benin Teaching Hospital and parental consents were granted.

Acute diarrhoea in this study was defined as the passage of unusually loose or watery stool at least 3 or more times in a 24-hour period lasting less than 14 days. While the level of dehydration was assessed and categorized as mild, moderate and severe using the World Health Organization (WHO) criteria [12]. The nutritional status of these children was assessed using the weight-for-age Z-scores for boys and girls from birth to five years (WHO child growth standard) [13]. The weight and age of each participant on admission was compared to the corresponding weight-for-age Z-score. Those with weight-for-age less than minus two standard deviations were classified as being undernourished. In assessing electrolyte and acid-base disturbances, hyponatraemia, hypernatraemia, hypokalaemia and metabolic acidosis were defined as serum sodium below 136 mmol/l, above 146 mmol/l, serum potassium below 3.5 mmol/l and serum bicarbonate below 20 mmol/l, respectively

Statistical analysis was done using SPSS for windows Version-16. Continuous variables are reported as mean value ± standard deviation. The mean were compared using the independent-samples T test for two groups and one-way analysis of variance for more than two groups. The p-value < 0.05 was considered to be statistically significant.

RESULTS

A total of 185 children met the inclusion criteria out of the 302 admitted for diarrhoeal disease during the study period. Of these, 107 (57.8%) were males and 78 (42.2%) were females with a male female ratio of 1.4:1. The mean age of the study population was 14.6 ± 10.5 months and a median of 12 (IQR: Q1–7, Q3–20). Electrolytes and acid base disturbances were observed in 165 (89.2%) of the children, most of whom (114 or 61.6%) were moderately dehydrated, while mild and severe dehydration accounted for 41 (22.2%) and 30 (16.2%), respectively. Dehydration was hyponatraemic in 112 (60.5%) children, hypernatraemic in 8 (4.3%) and isonatraemic in 65 (35.1%). More than half of the children (110 or 59.5%) had metabolic acidosis, while hypokalaemia occurred in 82 (44.3%) as shown in Table 1. In addition, a large proportion of the children studied (61.1%) were well nourished (WFA > 2 SD) even though weight at admission was used. Regarding the duration of illness before admission, most of the children (60%) were brought to the hospital before the third day of the illness. However, less than half (47%) of the parents/caregivers used any form of oral rehydration therapy, and the remainder (53%) either did nothing or inappropriately used drugs.

The comparison of mean serum sodium and potassium of the children with varying degrees of dehydration did not attain statistical significance, p = 0.46 and p = 0.64, respectively. However, bicarbonate concentration was significantly influenced by the degree of dehydration, p = 0.001 (Table 2). A turkey post-hoc comparison test revealed no statistically significant reduction in serum bicarbonate concentration between mild and moderate dehydration (p = 0.06), but there was a significant difference between moderate and severe (p = 0.03) and expectedly between mild and severe dehydration (p < 0.001), not shown on the table.

When serum sodium, potassium and bicarbonate were studied in relation to selected clinical parameters, a statistically significant association was found between hyponatraemia and children more than 12 months of age (p = 0.005, 95% CI 0.81, 4.35), presence of vomiting (p = 0.02, 95% CI −5.54, −0.55) and male gender (p = 0.03, 95% CI −3.90, −0.16). In contrast, a significant association was found between metabolic acidosis and children less than 12 months as well as absence of vomiting, p = 0.03, 95%

Table 1. Percentage Distribution of the clinical and laboratory parameters of patients

Characteristics	Number (%)
Gender	
Male	107 (57.8)
Female	78 (42.2)
Age	
≤ 12 months	103 (55.7)
> 12 months	82 (44.3)
Nutritional Status (WFA Z-score)	
< 2 SD	72 (38.9)
> 2 SD	113 (61.1)
Frequency of Diarrhoea in 24 hours	
≤ 6 times	130 (70.3)
> 6 times	55 (29.7)
Diarrhoea Duration at admission	
≤ 3 days	111 (60.0)
> 3 days	74 (40.0)
Associated Vomiting	
Present	155 (83.8)
Absent	30 (16.2)
Home Treatment	
Oral Rehydration Therapy (ORT)	87 (47.0)
Drugs/Nothing	98 (53.0)
Fever	
Present	109 (58.9)
Absent	76 (41.1)
Dyspnoea	
Present	25 (13.5)
Absent	160 (86.5)
Dehydration	
Mild	41 (22.2)
Moderate	114 (61.6)
Severe	30 (16.2)
Serum Sodium	
Hyponatraemia (< 136 mmol/l)	112 (60.5)
Isonatraemia (136–146 mmol/l)	65 (35.1)
Hypernatraemia (> 146 mmol/l)	8 (4.3)
Serum Potassium	
Hypokalaemia (< 3.5 mmol/l)	82 (44.3)
Normal (3.5–5.5 mmol/l)	101 (54.6)
Hyperkalaemia (> 5.5 mmol/l)	2 (1.1)
Serum Bicarbonate	
Metabolic Acidosis (< 20 mmol/l)	110 (59.5)
Normal (20–30 mmol/l)	74 (40.0)
Metabolic Alkalosis (> 30 mmol/l)	1 (0.50)

WFA: Weight for Age

CI −2.61, −0.17 and p = 0.04, 95% CI 0.10, 3.39, respectively. In the same vein, non-usage of oral rehydration therapy prior to admission and the presence of dyspnoea were also significantly associated with metabolic acidosis (Table 3).

DISCUSSION

Dehydration and disturbances in electrolyte balance are common complications of acute diarrhoeal disease in children [10]. This is because children exhibit major physiologic differences from adults in their total body surface area, immature renal structures, endocrine systems and higher metabolic rate. Each of these factors predisposes them to developmental variations in fluid and electrolyte balance [14]. This study, like others before it, found electrolyte abnormality in more than three quarters of the children [15, 16]. Specifically, 89.2% of the study population had one form of electrolyte disturbance or another. This is higher than the incidence reported previously in Thailand and Nepal [15, 16]. Our higher incidence may be attributable to the inappropriate treatment often given at home and/or inpatent medicine stores. Adimora et al. and Aguwa et al. reported a very poor knowledge of childhood diarrhoea treatment by both mothers and patent medicine dealers [17, 18]. The children are only brought to a health facility when the condition appears to be worsening. This may also explain why more than three quarters of the children had moderate or severe dehydration at admission.

Hyponatraemic dehydration was the commonest type of dehydration observed in our patients (60.5%). This was also observed by Shah et al. (56%) among Nepalese children [15]. However, Ukarapol et al. reported isonatraemic dehydration to be a more common finding [16]. The reason for the disparity could be the difference in the reference ranges used in the various studies. While a serum sodium level less than 136 mmol/l constituted hyponatraemia in our study, Ukarapol et al. defined hyponatraemia as serum sodium less than 130 mmol/l. This study also found a significant association between hyponatraemia and children more than 12 months of age, male gender as well as the presence of vomiting. Effiong et al. also reported hyponatraemia with increasing age but no effect of gender [11]. Hyponatremic dehydration most typically occurs in older infants and children with gastrointestinal infections [19, 20]. These children are often given fluids with low sodium content such as water, juice, ginger ale, sodas, or tea. In addition, ADH is often released, resulting in increased thirst leading to increased water intake, most of which is reabsorbed further, diluting the intravascular solute [21].

Hypokalaemia in this study was present in 44.3% of

Table 2.   Mean Electrolytes and acid-base levels in relation to degree of dehydration

Parameter	Degree of Dehydration			F	p-value
	Mild (n = 41)	Moderate (n = 114)	Severe (n = 30)		
Serum Sodium mmol/l ± SD	134.34 ± 4.70	133.68 ± 5.88	135.27 ± 9.71	0.77	0.46
Serum Potassium mmol/l ± SD	3.49 ± 0.45	3.57 ± 0.59	3.46 ± 1.02	0.46	0.64
Serum Bicarbonate mmol/l ± SD	19.88 ± 4.00	18.20 ± 3.59	16.07 ± 5.67	7.56	0.001

SD: Standard Deviation

Table 3.   Association between serum electrolytes and some clinical parameters

Parameter	Mean Na+ ± SD	p-value	95% CI	Mean K+ ± SD	p-value	95% CI	Mean HCO3 ± SD	p-value	95% CI
Age									
≤ 12 mths	135.22 ± 7.19	0.005	0.81, 4.35	3.59 ± 0.70	0.20	−0.07, 0.31	17.61 ± 4.48	0.03	−2.61, −0.17
> 12 mths	132.65 ± 4.99			3.47 ± 0.57			19.00 ± 3.77		
Fever									
Present	134.18 ± 7.16	0.88	−1.94, 1.65	3.53 ± 0.68	0.93	−0.19, 0.20	17.81 ± 4.57	0.08	−0.12, 2.27
Absent	134.04 ± 5.19			3.54 ± 0.61			18.88 ± 3.61		
Diarrhoea Frequency									
≤ 6 times	133.72 ± 6.25	0.24	−3.27, 0.81	3.54 ± 0.62	0.83	−0.18, 0.23	18.21 ± 4.41	0.92	−1.41, 1.28
> 6 times	134.95 ± 6.79			3.52 ± 0.72			18.27 ± 3.80		
Diarrhoea Duration									
≤ 3 days	134.63 ± 6.48	0.16	−0.52, 3.27	3.59 ± 0.61	0.12	−0.04, 0.34	18.51 ± 4.15	0.26	−0.54, 1.98
> 3 days	133.26 ± 6.29			3.44 ± 0.69			17.80 ± 4.32		
Vomiting									
Present	131.53 ± 7.45	0.02	−5.54, −0.55	3.57 ± 0.60	0.10	−0.04, 0.47	18.57 ± 4.18	0.04	0.10, 3.39
Absent	134.57 ± 6.11			3.36 ± 0.84			16.77 ± 4.20		
Home Treatment									
ORT	134.15 ± 6.05	0.89	−1.74, 2.00	3.57 ± 0.51	0.48	−0.12, 0.26	18.94 ± 3.70	0.03	0.14, 2.57
Drugs/nothing	134.02 ± 6.76			3.50 ± 0.76			17.59 ± 4.56		
Dyspnoea									
Present	135.96 ± 8.20	0.12	−0.54, 4.89	3.79 ± 0.70	0.03	0.03, 0.57	16.00 ± 5.09	0.004	−4.33, −0.82
Absent	133.79 ± 6.08			3.49 ± 0.63			18.56 ± 3.98		
Gender									
Male	133.22 ± 6.89	0.03	−3.90, −0.16	3.47 ± 0.70	0.11	−0.34, 0.04	18.51 ± 3.70	0.30	−0.56, 1.92
Female	135.26 ± 5.88			3.62 ± 0.57			17.83 ± 4.85		
Nutrition									
z-score									
< 2 SD	133.76 ± 5.70	0.40	−2.73, 1.09	3.52 ± 0.62	0.69	−0.23, 0.16	18.40 ± 3.92	0.49	−0.82, 1.70
> 2 SD	134.58 ± 7.43			3.56 ± 0.69			17.96 ± 4.68		

SD – Standard Deviation
Na+ Sodium
K+ Potassium
HCO3 Bicarbonate

the study population. This is similar to the 46% reported by Shah et al. [15] and 37.1% by Majeed et al. in Hyderabad, Pakistan [22]. The hypokalaemia observed in our study is probably due to increased potassium loss through diarrhoea; up to 100 meq/l of potassium may be lost in the stool [23]. Another risk factor for hypokalaemia is malnutrition [24], but we found no significant association in this study between hypokalaemia and children whose weight for age were less than 2-SD. A possible explanation for this is that some of the children may have

been misclassified as having malnutrition since acute diarrhoea with dehydration can cause acute weight loss. Their corrected weight (after rehydration) may have been slightly higher and may no longer have met one of the criteria (less than 2-SD weight-for-age) for malnutrition.

Acid-base disturbances are also common findings in children with acute diarrhoea especially metabolic acidosis. The most common explanations for the occurrence of metabolic acidosis in acute diarrhoea include bicarbonate loss in stool, ketone production from starvation, and lactic acid production from decreased tissue perfusion in hypovolemia. Decreased renal perfusion also causes a decreased glomerular filtration rate, which, in turn, leads to decreased hydrogen (H^+) ion excretion [25]. In our study, 59.5% of the patients had metabolic acidosis, and, with increasing levels of dehydration, there was a concomitant reduction in serum bicarbonate concentration. The difference was more significant between moderate and severe but less so between mild and moderate. Some other studies however have reported no significant difference in the serum bicarbonate concentration in relation to the degree of dehydration [26, 27]. This study has also shown that metabolic acidosis following acute diarrhoeal disease was more common than previously reported in children less than 12 months of age [15]. Infants' higher body water content, along with their higher metabolic rates and increased body surface area to mass index, contribute to their higher turnover of fluids and solute and greater susceptibility to volume depletion [25].

It is important to note that the clinical characteristics of acute diarrhoeal disease, and to some extent the associated complications, may be related to the aetiologic agent [28]. However, in this study, the determination of the aetiologic agents was not done, making it impossible to state as to what extent it influenced the outcome. This is a limitation that future studies can explore.

In conclusion, electrolyte and acid base disturbances are very common in children with acute diarrhoea disease. The degree of dehydration and age less than 12 months appear to be good predictors of the occurrence of metabolic acidosis and children more than 12 months of age are at greatest risk of hyponatraemia. In order to optimize management, therefore, it is recommended that infants presenting with moderate to severe dehydration due to acute diarrhoeal disease should always be evaluated for their electrolytes and acid-base status.

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